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COMBINING ABILITY STUDIES IN BOTTLE GOURD [*LAGENARIA SICERARIA*(MOL.) STANDL]

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ABSTRACT

Combining ability analysis was undertaken using ten diverse lines and their 45 F_1 hybrids of bottle gourd developed through diallel fashion excluding reciprocals. The experimental material were evaluated in a randomized complete block design with two replications at the Main Vegetable Research Station, Anand Agricultural University, Anand, during kharif, 2016. Analysis of variance for combining ability indicated significant importance of both additive and non-additive genetic variance for inheritance of all the characters, except for days to opening of first male flower and days to opening of first female flower.The potence ratio and predictability ratio suggestedpreponderanceof non-additive gene action for all the characters except for days to opening of first male flower and days to opening of first female flower. Estimates of general combining ability (GCA) effects showed that Punjab Komal and DBG 6 were good general combiners for most of the characters imparting earliness. While, ABGS 11-23 was a good general combiner for the quality characters. The cross combination ABGS 11-23 x DBG 5 showed highest specific combining ability (SCA) effects for fruit yield per plant, whereas, ABGS 11-17 x Arka Bahar was found to be the best specific combination for days to opening of first male flower, days of opening of a first female flower and days to first picking.

KEYWORDS: Bottle Gourd, General Combining Ability, Hybrid, Lagenaria Siceraria & Specific Combining Ability

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Original Article

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is an important gourd having wide range of uses and is largely cultivated in the tropics and subtropics for its edible fruits. Identification of suitable parents with good combining ability and derivation of best F_1 hybrids having better specific combining ability are prerequisite for exploitation of heterosis in desirable direction. The combining ability analysis also helps in characterizing the nature and magnitude of gene action controlling the inheritance of different traits. The diallel cross analyses has been found as an useful biometrical technique for understanding the nature of quantitatively inherited traits and to ascertain the property of parents by the estimation of general and specific combining abilities. An added advantage of the diallel analysis is that it provides an overall genetic picture of experimental material in a single generation. Therefore, the present investigation was undertaken with the objective to study combining ability effects and gene action for nine characters in a diallel mating design (excluding reciprocals) using ten parents of bottle gourd.

MATERIALS AND METHODS

The experimental material comprised of 10 diverse lines viz., ABG 1, ABGS 11-17, ABGS 11-22, ABGS 11-23, DBG 6, Pusa Naveen, PSPL, Arka Bahar, DBG 5 and Punjab Komal of bottle gourd. The crosses were

made in diallel fashion excluding reciprocals, during *kharif* 2015. The 45 F_1 hybrids along with their 10 parents were evaluated in a randomized complete block design with two replications at the Main Vegetable Research Station, Anand Agricultural University, Anand, during *kharif*, 2016. Each experimental unit was represented by a single row accommodating seven plants with inter and intra row spacing of 2 and 1 meter, respectively.The recommended cultural practices and plant protection measures obligatory to raise healthy crop were followed. Observations were recorded on net five plants in each experimental unit for five maturity characters viz., days to opening of first male flower, days to opening of first female flower, first male flowering node number, first female flowering node number and days to first picking from the date of sowing, three quality characters viz., total soluble solids (˚Brix), total sugar content (%) and total chlorophyll content (mg/100 g) and for fruit yield per plant (kg). The combining ability analysis was calculated according to Model I, Method 2 suggested by Griffing (1956). The relative importance of general or specific combining ability variances was worked out through potence ratio $[(\frac{1}{df}\sigma^2_{GCA})/(\frac{1}{df}\sigma^2_{SCA})]$ and predictability ratio $[2\sigma^2_{GCA}/(2\sigma^2_{GCA}+\sigma^2_{SCA})]$.

RESULTS AND DISCUSSIONS

The analysis of variance for combining ability presented in Table 1 revealed that mean squares due to GCA and SCA were significant for all the characters, except SCA for days to opening of first male flower and days to opening of first female flower,indicating significant importance of both additive and non-additive genetic variances in the inheritance of most of the characters.However, the potence ratio of both the components of genetic variance was above one (unit) for days to opening of first male flower, days to opening of first female flower and days to first picking, which suggested preponderance of additive genetic variance in the expression of these traits. The lower estimate (below one) of potence ratio for rest of the character indicated that non-additive gene action was pronounced for inheritance of these traits. The below 0.5 values of predictability ratio for all the characters except for days to opening of first male flower and days to opening of first female flower revealed preponderance of variance due to specific combining ability for their genetic control. Similar findings were reported in bottle gourd by Dubey and Maurya (2003), Sharma et al. (2007), Adarsh et al. (2015) and Shinde et al. (2016). Significance of only additive gene effect fordays to opening of first male flower and days to opening of first female flower were also reported by Vegad et al. (2011).

The estimates of general combining ability (GCA) effects of parents (Table 2) revealed that Punjab Komal and Arka Bahar recorded highly significant positive GCA estimates for fruit yield per plant. Punjab Komal and DBG 6 were good general combiners for days to opening of first male flower and days to opening of first female flower. Punjab Komal, DBG 6 and ABG 1 showed desirable GCA estimates for first male flowering node number, while Punjab Komal, DBG 6 and DBG 5 were good general combiners for first female flowering node number. However, only Punjab Komal was a good general combiner for days to first picking.Whereas, ABGS 11-23, DBG 6 and Punjab Komal recorded desirable GCA estimates for total soluble solids and total sugar content. For total chlorophyll content, ABGS 11-23, Arka Bahar and ABG 1 were good general combiners.

The SCA effects of crosses presented in Table 3 revealed that the cross combination ABGS 11-23 x DBG 5 (3.06) for fruit yield per plant, ABGS 11-17 x Arka Bahar (-2.64) for days to opening of first male flower,ABGS 11-17 x Arka Bahar (-4.28) for days to opening of first female flower, ABGS 11-22 x ABGS 11-23 (-5.54)for first male flowering node number, ABGS 11-23 x DBG 5 (-5.24) for first female flowering node number, ABGS 11-17 x Arka Bahar (-5.61) for days to first picking, ABG 1 x Arka Bahar (1.24) for total soluble solids,ABG 1 x DBG 5 (1.81) for total sugar content and Pusa

Naveen x DBG 5 (0.72) for total chlorophyll content exhibited the maximum SCA effect. These cross combinations may be exploited for practical plant breeding programme to yield transgressive and stable performing segregate possessing enhanced yielding ability.

CONCLUSIONS

The nature and magnitude of components of genetic variance provide an idea about the relative importance of additive and non-additive gene effects in the inheritance of matricate character. In the present study, only additive genetic variance was significant for the genetic control of the characters, days to opening of first male flower and days to opening of first female flower, while, for rest of the characters non-additive genetic variance was of greater magnitude.The results also revealed that Punjab Komal and DBG 6 were good general combiners for most of the characters imparting earliness. While, ABGS 11-23 was a good general combiner for the quality characters. These parents may be used in future breeding programmes for simultaneous improvement of most of the important attributes in addition to heterosis breeding. It is impressed from the Table 4 that the parents *per se* performance had resulted in desirable GCA effect of respective parent. Therefore, in selection of parents for hybridization due weightage should also be given to their *per se* performance along with their GCA effect.

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APPENDICES

Table 1: Analysis of Variance for Combining Ability and Genetic Components for 10 X 10 Diallel Cross in Bottle Gourd

Character	Source of Variation and Genetic Components						
	Parents(GCA)	Hybrids (SCA)	Error	σ^2_{GCA}	σ^2_{SCA}	Potence Ratio	Predictability Ratio
Degree of Freedom	**[9]**	**[45]**	**[54]**	**-**	**-**	**-**	
Fruit yield per plant	1.60**	1.61**	0.18	0.00	1.43	-	-
Days to opening of first male flower	15.29**	2.40	2.31	1.07	0.09	59.68	0.96
Days to opening of first female flower	19.64**	4.07	2.61	1.30	1.46	4.44	0.64

Table 1: Contd.,							
First male flowering node number	13.81**	5.09**	0.99	0.73	4.10	0.89	0.26
First female flowering node number	17.15**	6.48**	1.46	0.89	5.02	0.89	0.26
Days to first picking	35.23**	11.94**	5.53	1.94	6.41	1.51	0.38
Total soluble solids	0.343**	0.236**	0.009	0.01	0.23	0.20	0.07
Total sugar content	0.91**	0.62**	0.03	0.02	0.59	0.20	0.08
Total chlorophyll content	0.17**	0.11**	0.004	0.01	0.11	0.24	0.09

*, ** significant at 0.05 and 0.01 probability levels, respectively. For fruit yield per plant, estimates of σ^2_{GCA} were negative, hence considered as zero.

Table 2: Estimates of General Combining Ability (GCA) Effect of Parents for Different Characters in Bottle Gourd

Genotypes	Character								
	FYP	DOFMF	DOFFF	FMFN	FFFN	DFP	TSS	TSC	TCC
ABG 1	-0.56**	0.95**	0.97*	-0.54*	-0.48	1.04	0.00	0.02	0.05**
ABGS 11-17	-0.37**	0.13	0.78	1.21**	1.22**	0.54	-0.13**	-0.24**	-0.03*
ABGS 11-22	0.06	1.42**	0.38	1.11**	0.77*	-0.29	-0.13**	-0.26**	-0.09**
ABGS 11-23	-0.10	0.55	0.21	0.53*	-0.12	0.50	0.40**	0.68**	0.26**
DBG 6	0.19	-1.26**	-1.09*	-1.60**	-1.22**	-0.75	0.14**	0.17**	-0.16**
Pusa Naveen	0.21	-0.38	-0.21	-0.34	0.03	-1.00	-0.12**	-0.16**	0.02
PSPL	-0.34**	0.74	1.80**	0.91**	1.70**	2.96**	-0.08**	-0.06	-0.06**
Arka Bahar	0.45**	0.21	0.30	0.50	0.99**	0.21	-0.09**	-0.11*	0.12**
DBG 5	-0.12	0.07	-0.26	0.05	-0.73*	0.54	-0.08**	-0.14**	-0.10**
Punjab Komal	0.58**	-2.43**	-2.89**	-1.82**	-2.16**	-3.75**	0.10**	0.11*	-0.02
S.E.(g_i)±	0.11	0.11	0.44	0.27	0.33	0.64	0.02	0.05	0.01
C.D. (g_i) at 5 %	0.23	0.81	0.86	0.53	0.64	1.26	0.05	0.10	0.03
C.D. (g_i) at 1 %	0.30	1.06	1.14	0.70	0.85	1.66	0.06	0.13	0.04

*, ** significance at 5% and 1%, respectively. Characters : Fruit yield per plant (FYP), Days to opening of first male flower (DOFMF), Days to opening of first female flower (DOFFF), First male flowering node number (FMFN), First female flowering node number (FFFN), Days to first picking (DFP), Total soluble solids (TSS), Total sugar content (TSC) and Total chlorophyll content (TCC).

Table 3: Estimates of Specific Combining Ability (SCA) Effect of Hybrids forDifferent Characters in Bottle Gourd

Hybrids	Fruit yield per Plant	Days to Opening of First Male Flower	Days to Opening of First Female Flower	First male Flowering Node Number	First Female Flowering Node Number	Days to First Picking	Total Soluble Solids	Total Sugar Content	Total Chlorophyll Content
ABG 1 x ABGS 11-17	-1.18**	0.02	1.16	1.43	1.87	1.05	-0.17*	-0.20	-0.20**
ABG 1 x ABGS 11-22	-1.08**	-1.57	-2.44	2.24*	-1.18	-0.11	-0.27**	-0.63**	0.36**
ABG 1 x ABGS 11-23	0.65	-2.10	-2.57	-1.29	-2.39*	-2.91	-0.45**	-0.57**	0.25**
ABG 1 x DBG 6	0.63	0.21	0.73	1.94*	1.70	1.34	-0.59**	-1.50**	-0.05
ABG 1 x Pusa Naveen	-0.88*	0.92	-0.15	-1.21	-0.74	-1.91	0.12	0.29	-0.43**
ABG 1 x PSPL	1.45**	-1.59	-2.46	-1.97*	-1.32	-3.86	-0.07	0.03	-0.15**
ABG 1 xArka Bahar	1.94**	-1.76	-3.06*	0.64	0.69	-5.61**	1.24**	1.79**	-0.50**
ABG 1 xDBG 5	-0.88*	1.38	3.11*	2.39**	4.02**	6.05**	1.03**	1.81**	0.03
ABG 1 xPunjab Komal	0.54	1.88	3.33*	-0.94	0.24	2.84	-0.35**	-0.44*	-0.36**
ABGS 11-17 x ABGS 11-22	0.87*	0.75	0.24	0.88	0.52	-0.61	-0.14	-0.30	-0.23**
ABGS 11-17 x ABGS 11-23	0.25	-0.08	0.02	0.65	3.11**	1.09	0.58**	1.24**	-0.25**
ABGS 11-17 x DBG 6	0.47	-1.67	-1.58	-3.51**	-1.30	-4.16	-0.45**	-1.21**	-0.08
ABGS 11-17 x Pusa Naveen	0.79*	-0.96	-1.37	0.63	0.86	-2.91	-0.14	-0.62**	-0.30**
ABGS 11-17 x PSPL	-1.31**	0.33	-0.98	1.67	1.38	2.64	-0.04	0.04	-0.22**
ABGS 11-17 x Arka Bahar	-0.44	-2.64	-4.28**	-2.82**	-2.51*	-5.61**	0.17*	0.47**	0.42**

Table 3: Contd.,									
ABGS 11-17 xDBG 5	0.58	0.00	-1.31	-1.26	-0.38	2.05	-0.24**	-0.64**	-0.19**
ABGS 11-17 x Punjab Komal	0.41	0.20	-0.18	1.00	1.94	1.34	-0.22*	-0.19	-0.30**
ABGS 11-22 x ABGS 11-23	1.03**	-0.57	1.32	-5.54**	-3.64**	-1.57	0.98**	1.28**	0.16**
ABGS 11-22 x DBG 6	-0.31	3.54*	1.82	3.39**	2.85*	-0.32	-0.26**	-0.16	-0.06
ABGS 11-22 x Pusa Naveen	0.30	-1.24	0.03	-1.16	-0.29	1.93	0.25**	0.56**	0.08
ABGS 11-22 x PSPL	0.21	0.54	-0.38	0.78	1.33	2.47	-0.04	-0.01	0.03
ABGS 11-22 x Arka Bahar	0.19	-0.92	-0.88	-0.91	-1.16	-2.28	-0.14	-0.23	-0.33**
ABGS 11-22 xDBG 5	-1.36**	-0.98	-2.01	1.74	2.37*	1.89	-0.04	0.11	-0.10
ABGS 11-22 xPunjab Komal	0.12	-2.48	-2.38	1.21	0.09	-2.82	-0.13	0.16	0.32**
ABGS 11-23 xDBG 6	-0.57	-1.29	-2.51	-1.43	-1.86	2.89	0.81**	0.86**	0.32**
ABGS 11-23 x Pusa Naveen	0.35	0.03	-1.79	1.11	-2.90**	-1.86	-0.58**	-1.01**	-0.43**
ABGS 11-23 x PSPL	-2.35**	0.81	2.20	3.05**	3.52**	6.18**	0.43**	0.87**	-0.13*
ABGS 11-23 xArka Bahar	-0.41	1.94	2.10	2.86**	4.83**	7.93**	-0.16	-0.29	0.20**
ABGS 11-23 xDBG 5	3.06**	-0.52	-1.03	-1.08	-5.24**	-4.91*	-0.37**	-0.45*	0.10
ABGS 11-23 x Punjab Komal	-1.63**	0.98	1.69	3.19**	4.08**	-0.11	-0.35**	-0.48**	0.30**
DBG 6 x Pusa Naveen	-0.02	-0.87	1.21	-2.56**	-2.71*	4.89*	-0.27**	-0.26	0.02
DBG 6 x PSPL	1.08**	0.72	-1.2	0.29	-4.18**	0.93	0.39**	0.63**	0.21**
DBG 6 x Arka Bahar	-0.24	0.15	0.30	1.89*	0.52	-2.32	-0.30**	-0.31	-0.25**
DBG 6 xDBG 5	1.69**	-1.41	-1.23	-0.95	0.65	-4.66*	0.59**	1.16**	-0.10
DBG 6 x Punjab Komal	0.55	0.19	0.09	0.32	1.27	-0.86	-0.49**	-0.59**	-0.12*
Pusa Naveen x PSPL	-1.53**	1.43	1.52	1.83*	2.77*	-1.82	0.15	0.29	-0.17**
Pusa Naveen xArka Bahar	0.63	0.47	1.52	2.04*	1.98	-0.57	-0.04	0.02	0.50**
Pusa Naveen xDBG 5	0.01	0.81	0.08	3.29**	2.31*	-2.91	-0.15	-0.39*	0.72**
Pusa Naveen x Punjab Komal	-1.48**	1.31	1.11	-0.54	0.43	-0.11	-0.33**	-0.59**	0.67**
PSPL xArka Bahar	0.99*	4.15**	5.01**	3.08**	1.51	5.47*	-0.28**	-1.00**	0.58**
PSPL xDBG 5	-1.13**	-0.91	0.57	-3.56**	-2.17	0.14	-0.09	-0.13	0.00
PSPL x Punjab Komal	-0.35	-1.31	-0.90	-0.70	0.36	-4.57*	-0.27**	-0.34	-0.22**
Arka Bahar xDBG 5	-1.70**	1.92	0.57	-1.06	-3.06**	3.89	-0.08	-0.10	-0.35**
Arka Bahar x Punjab Komal	0.20	-1.07	-0.10	-0.29	-0.83	-2.32	-0.27**	-0.32	0.41**
DBG 5 x Punjab Komal	-0.91*	0.57	0.17	3.07**	2.79*	-0.66	-0.27**	-0.28	-0.19**
S.E. (S_{ij})±	0.40	1.40	1.48	0.91	1.11	2.16	0.09	0.18	0.05
S.E. ($S_{ij} - S_{kl}$)±	0.56	1.96	2.08	1.28	1.56	3.03	0.12	0.25	0.08

*, ** indicate level of significance at 5% and 1%, respectively.

Table 4: Better Performing Parents (*Per Se* and GCA) and Hybrids (*Per Se*andSCA) for Different Characters

Characters	Parental Performance		Top Ranking Hybrids	
	Per se	GCA	*Per se*	SCA
Fruit yield per plant	Punjab Komal (6.91) Pusa Naveen (5.82) PSPL (5.27)	Punjab Komal (0.58) Arka Bahar (0.45) Pusa Naveen (0.21)	ABGS 11-23 x DBG 5 (7.32) ABG 1 x Arka Bahar (6.32) DBG 6 x DBG 5 (6.24)	ABGS 11-23 x DBG 5 (3.06) ABG 1 x Arka Bahar (1.94) DBG 6 x DBG 5 (1.69)
Days to opening of first male flower	Punjab Komal (38.30) DBG 6 (41.00) Pusa Naveen (41.60)	Punjab Komal (-2.43) DBG 6 (-1.26) Pusa Naveen (-0.38)	ABGS 11-22 x Punjab Komal (39.80) DBG 6 x Punjab Komal (39.80) Arka Bahar x Punjab Komal (40.00)	ABGS 11-17 x Arka Bahar (-2.64) ABGS 11-22 x Punjab Komal(-2.48) ABG 1 x ABGS 11-23 (-2.10)
Days to opening of first female flower	Punjab Komal (39.40) Pusa Naveen (45.10) DBG 6 (45.60)	Punjab Komal (-2.89) DBG 6 (-1.09) DBG 5 (-0.26)	ABGS 11-22 x Punjab Komal (41.70) DBG 6 x Punjab Komal (42.70) ABGS 11-23 x DBG 6 (43.20)	ABGS 11-17 x Arka Bahar (-4.28) ABG 1 x Arka Bahar (-3.06) ABG 1 x ABGS 11-23 (-2.57)

Table 4: Contd.,				
First male flowering node number	Punjab Komal (13.30) DBG 6 (17.20) ABG 1(17.40)	Punjab Komal (-1.82) DBG 6 (-1.60) ABG 1 (-0.54)	DBG 6 x Pusa Naveen (15.60) ABGS 11-17 x DBG 6 (16.20) ABGS 11-22 x ABGS 11-23 (16.20)	ABGS 11-22 x ABGS 11-23 (-5.54) PSPL x DBG 5 (-3.56) ABGS 11-17 x DBG 6 (-3.51)
First female flowering node number	Punjab Komal (17.00) ABG 1 (24.10) DBG 5 (24.40)	Punjab Komal (-2.16) DBG 6 (-1.22) DBG 5 (-0.73)	ABGS 11-23 x DBG 5 (20.40) DBG 6 x Pusa Naveen (22.60) DBG 6 x PSPL (22.80)	ABGS 11-23 x DBG 5 (-5.24) DBG 6 x PSPL (-4.18) ABGS 11-22 x ABGS 11-23 (-3.64)
Days to first picking	Punjab Komal (52.50) ABGS 11-23 (54.00) DBG 6 (56.00)	Punjab Komal (-3.75) Pusa Naveen (-1.00) DBG 6 (-0.75)	ABGS 11-22 x Punjab Komal (49.50) Arka Bahar x Punjab Komal (50.50) DBG 6 x Punjab Komal (51.00)	ABG 1 x Arka Bahar (-5.61) ABGS 11-17 x Arka Bahar (-5.61) ABGS 11-23 x DBG 5 (-4.91)
Total soluble solids	Punjab Komal (3.80) DBG 6 (2.80) ABGS 11-23 (2.60)	ABGS 11-23 (0.40) DBG 6 (0.14) Punjab Komal (0.10)	ABGS 11-23 x DBG 6 (3.60) ABGS 11-22 x ABGS 11-23 (3.50) ABG 1 x Arka Bahar (3.40)	ABG 1 x Arka Bahar (1.24) ABG 1 x DBG 5 (1.03) ABGS 11-22 x ABGS 11-23 (0.98)
Total sugar content	Punjab Komal (5.09) DBG 6 (4.37) ABGS 11-23 (3.98)	ABGS 11-23 (0.68) DBG 6 (0.17) Punjab Komal (0.11)	ABGS 11-23 x DBG 6 (5.05) ABG 1 x Arka Bahar (5.04) ABGS 11-22 x ABGS 11-23 (5.04)	ABG 1 x DBG 5 (1.81) ABG 1 x Arka Bahar (1.79) ABGS 11-22 x ABG 11-23 (1.28)
Total chlorophyll content	ABG 1 (2.01) ABGS 11-17 (2.01) ABGS 11-23 (1.64)	ABGS 11-23 (0.26) Arka Bahar (0.12) ABG 1 (0.05)	Pusa Naveen x Punjab Komal (2.05) Pusa Naveen x Arka Bahar (2.02) Pusa Naveen x DBG 5 (2.02) PSPL x Arka Bahar (2.02)	Pusa Naveen x DBG 5 (0.72) Pusa Naveen x Punjab Komal (0.67) PSPL x Arka Bahar (0.58)